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Assessment of the amount of coniferous wood waste in the Baltic States

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Abstract

The study was conducted in order to ascertain whether there is a sufficiently large amount of coniferous wood residue in the Baltic States to make the investigation of its rational use as a raw material for production feasible. Greenery (fine branches and needles) is the least used portion of coniferous wood residue; consequently, this study focuses on this part of forestry residue. The method of tree greenery weight per 1 m^3 of tree trunk was used to determine the amount of coniferous greenery. The approximate amount of coniferous greenery, produced from logging in the Baltic countries, is determined. It constitutes about 700 thousand tons per year in the Baltic States. That is enough large volume to look for an application and start using this resource as a raw material in further research.

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1. Introduction

All Baltic countries are among the most densely forested states in Europe [1]. Forest resources are one of their greatest assets, as they have small non–renewable natural resource deposits. Thus, the forest plays an important role not only as a repository of biological diversity, but also as a valuable natural resource. In order to maintain the biodiversity value of the forests, it is necessary to handle forest resources rationally and with consideration to the future, even though it is a renewable natural resource.

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2010 year data are used as an example of the use of wood recourses. According to the State Forest Service data, 3 020 575 hectares are currently occupied by forest in Latvia [2]. The largest part of this area (53.1 %) is occupied by conifers – 18.1 % by spruce (520 038.3 ha) and 35 % (1 003 625.2 ha) by pine. According to the Eurostat statistics database, forestry land in Estonia occupies 2 203 100 ha with a total wood volume of 441.4 million m^3 [1]. 50 % of the total forest area consists of coniferous – 34 % of pine and 16 % of spruce. Lithuanian forests cover nearly as much area (2 165 000 ha) and the total wood volume is about 479.4 millions m^3. Conifers also dominate in Lithuania (55.9 %) – 35.1 % are occupied by pine, and 20.8 % by spruce. The Baltic States have different proportions of private forest owners and the state–owned forest areas. The largest private forest area is in Estonia (61 %), but in Latvia it is 51 % and Lithuania – 37 % from the total wood land.

Wood is primarily used for the output of round wood or other products for exportation. The rest of the wood pulp is used as a fuel in the form of wood chips, pellets or firewood (Table 1). The majority of the appropriately used wood pulp is coniferous wood (about 11.033 thousand m^3/year). This confirms that coniferous trees are dominating in this region as they are the most harvested and utilized.

About 935 thousand m^3 (~3.3 %) of wood resources are left as a waste each year in the Baltic States. This is the useful timber amount only. During logging and wood processing, a large amount of additional residue is produced. In order to determine whether forest resources are completely and efficiently used, it is necessary to examine the causes of residue, their estimated amount and possible applications.

Table 1. Amount of round wood and other wood production in the Baltic States (thousand m^3/year) [1]

	Round wood						Waste and pellets	
		Industrial round wood						
Country	Total	Total	Coniferous	Deciduous trees	Fuel	Woodchips	Total	Pellets
Latvia	10409	8673	6412	2261	1736	2847	890	672
Lithuania	5460	3677	2123	1554	1783	835	683	278
Estonia	4860	3709	2498	1211	1152	1700	800	488
Total	20729	16059	11033	5026	4671	5382	2373	1438

A conclusion can be made that the majority of the wood usage possibilities constitutes residues, which also might be used. Mostly the woody part of forest and wood processing residue is used as a fuel in the form of firewood, wood chips or pellets. Wood, which is used as a source of energy (fuel), does not evolve from the cutting of trees only, but also from random felling, thinning and other forestry processes (direct sources). Wood for energy production can be obtained as a byproduct from timber production, for example, scrap, sawdust or chips (indirect sources). Wood and paper products can also be used as a fuel at the end of their life cycle [1].

As mentioned above, needles and branches may represent more than 20 % of the total weight of coniferous wood. Thus, it turns out that when needles are not used approximately one fifth of the conifer resources are wasted. Leaving needles of coniferous trees in the woods do not cause any harm to the environment. They disintegrate during natural processes. Nevertheless, the question about the rational utilization of the recourses remains open. Once the tree is cut we should make maximum use of the obtained material and produce energy or products that would otherwise require non–renewable resources or some synthetic compounds, which could harm the environment and human health during their life cycle. If all the biomass from logging would be used to its fullest potential, the profit from forestry would increase. Products from local raw materials would contribute to the local economy and reduce the negative impact that is formed by importing goods from distant production sites.

2. Methodology

It is assumed that approximately only 55 % of the total volume of wood stock are trunks, which are considered to be the most valuable raw material. The rest – 20 % are stumps and 25 % wreath – are considered to be forestry residue.

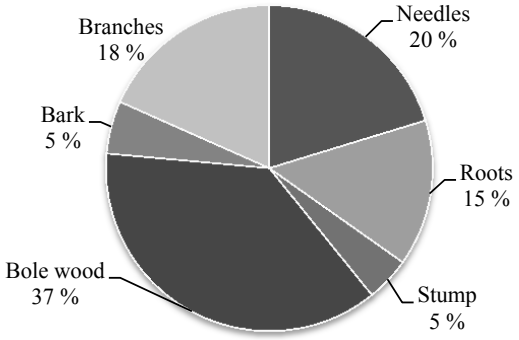

Fig. 1. Approximate wood biomass breakdown by its components [3]

For pine and spruce biomass, the distribution could be different. From the total biomass of coniferous wood, approximately 37 % are bole wood (trunks), 20 % needles, 18 % branches, 15 % roots, 5 % bark and 5 % stump (Fig. 1) [3]. Coniferous trees have a bigger average mass of greenery than other trees; therefore there is a larger amount of forestry residue as well.

Accurate results can be obtained in case of precise input data about a specific forest. It is possible to determine the amount of greenery precisely if the parameters of trees (age, height, and diameter) and growing conditions are known. It is necessary to use a more general method, because of the lack of access to such detailed information on Baltic coniferous forests; therefore, the resulting data are indicative and are not entirely accurate.

Several methods for the determination of the amount of coniferous greenery in Latvia have been developed by Latvian scientist U. Stibe during the study 'Tree crown elements of quantitative indicators logging old–age spruce forest' [4]:

- weight of greenery in tree groves per 1 ha;
- weight of tree greenery per 1 m^3 of tree trunk ;
- amount of tree greenery per 1 m^2 of grooves basal area.

These methods were developed through research and analysis of existing spruce forests in Latvia. This guarantees that these methods are suitable for the determination of the amount of spruce tree greenery in Latvia and nearby areas (the Baltic States). Without detailed data the developed and applied calculation methods from other regions are not applicable for coniferous greenery determination in Baltic States. Coniferous greenery constant values to one unit (ha, m^2 or m^3) are different in different climatic zones, the trees growing place affects the amount of greenery. Selection of the method also depends on the availability of data necessary for the calculations. The results obtained using different methods may vary approximately by ± 12.8 % [4]. If it is not possible to get the raw data to make control calculations by various methods, it is recommended to use the precise raw data available.

The abovementioned study was conducted only for the calculations of spruce tree greenery. Study on the determination of the amount of greenery for pine trees with the weight of tree greenery per 1 m^3 of tree trunk method was performed by the Latvian State Forest Research Institute 'Silava' [5]. Thus, this method is used to calculate the amount of greenery for both spruce and pine trees.

Data from Latvia are used to show the calculation process. According to the State Forest Service [2], current data on the Latvian dominant tree species and timber volume m^3 per ha of occupied area, can be obtained. The species of

trees and data on them are divided by tree age, with 10 year intervals. Thus, it is possible to select data for the wood of necessary age and species. This study specifically focuses on spruce and pine tree resources in the felling age. Younger trees are not included in the calculations, although it is possible that they are also harvested (final cuttings or deforestation by illegal forest logging) due to lack of accurate data on these volumes.

The necessary age of main felling in order to obtain cutting permits (the smallest forest stand age of the dominant tree species to be achieved in order to start the cutting of forest felling) is determined by law [6]. Felling age for spruce of any productivity class is 81 years. For pine it is 101 years (I–III class productivity group) or 121 years (IV class productivity group).

Legislation does not determine the maximum age of trees when they cannot be felled, and should be recognized as secular trees [6, 7]. However, legislation [6, 8] determines that a tree of a local or foreign species is recognized as the secular and protected if its circumference of 1.3 meters above the tree root collar are at least 2.5 m for Scots pine (*Pinus sylvestris*) and at least 3.0 m for spruce (*Picea abies*). It is impossible to determine trees circumference by its age, as it is influenced by numerous factors (such as soil type, moisture, geographic location, etc.). Therefore, data on pine trees in the age group from 101 and 201 and more and spruce in the 81 to 201 age range and more are used for the determination of the amount of greenery in this study.

Using "tree greenery mass on trunk wood 1 m^3" method, the output data selection for all available coniferous greenery is schematically shown in Figure 2.

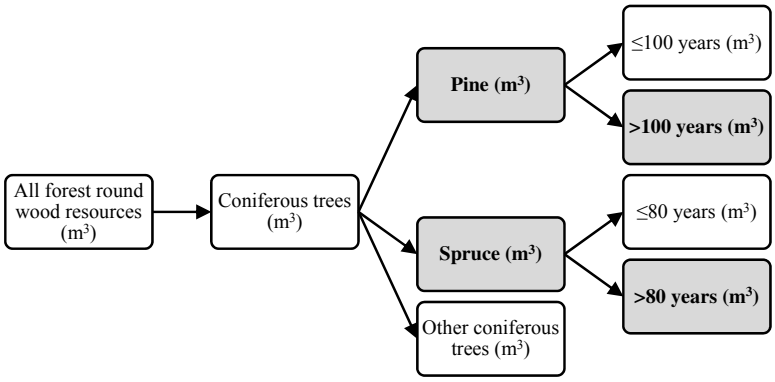

Fig. 2. Scheme of selection of available data determination for coniferous greenery

The "tree greenery mass on trunk wood 1 m^3" method is used for pine greenery calculations in the Latvian State Forest Research Institute "Silava". The average pine greenery quantity on trunk wood 1 m^3 is 78 kg [5]. For further calculations this value is used. It is possible to get 5 654 795 t of fresh greenery from the currently existing Latvian pines with the age from 101 to 201 and with the total amount of wood 72 497 375 m^3 [2].

The calculation of the amount of spruce greenery in Latvian conditions is based on two methods – the weight of tree greenery per 1 ha and the weight of greenery per 1 m^3 tree bole wood. Accurate and reliable data from single information source that will allow a correct comparison between the results are available for both methods.

The weight of spruce greenery per 1 m^3 of bole wood ranges from 98 kg to 175 kg. The heaviest greenery per 1 m^3 of tree trunk is observed in new stands, for example, for a 50–year–old grown Ia productivity group it is 175 kg, but in 80 and 100 years old stands greenery weight per 1 m^3 bole wood has little difference and there is no certain pattern. Comparison of the weight of spruce greenery per 1 m^3 of bole wood in stands with various productivity indexes showed that in better growing conditions the weight of greenery per 1 m^3 of spruce bole wood reduces.

Greenery weight on 1 m^3 of bole wood for productivity classes Ia, Ib, and I has very small differences, the average amount of greenery was calculated for all of these three stand productivity classes. It is 111.2 kg. The

average weight of the greenery on 1 m^3 of bole wood for all 4 productivity classes (Ia, Ib, I and II) together is 117.7 kg [4].

In the absence of more detailed information on the current volume of greenery for stands of different class productivity, the above mentioned average weight of greenery per 1 m^3 of bole wood was used for further study. If there currently are 27 147 644 m^3 of spruce stand in felling age in Latvia (from age 81 till 201 and more) than 3 195 278 t of fresh spruce greenery can be obtained from it.

A significant amount of greenery can be obtained from 1 ha of spruce stand. The amount of spruce greenery per 1 ha varies from 29.3 to 56.7 t; the majority of stands are from 36 to 50 t per 1 ha (Stibe, 1976). The acquired amount of greenery varies in such amplitude because it is influenced by various factors such as: density of the stand, productivity group, tree age. For calculations of the amount of greenery, the arithmetic average amount of greenery per 1 ha (43 t per ha) is used. Currently, spruce stand of cutting age occupies the area of 83 250 hectares of forest land in Latvian. From this area 3 579 737 t of greenery could be obtained.

The calculated amount of greenery with these two methods differs by 10.7 %. Thus, differences in these calculations are within the permissible limits and the obtained results are considered to be correct. The results obtained from using the weight of the greenery per 1 m^3 bole wood are used to determine the total amount of spruce greenery, because such information is available for all Baltic countries separately by coniferous species (spruce and pine). In Latvia the amount of fresh coniferous greenery is approximately 8 850 073 tons.

During the flagging part of tree branches, greenery breaks off and is damaged so it cannot be collected with equipment and used. This leads to the loss of greenery, which remains in the felling and decays. According to the information available in the literature [5], greenery loss is 12 – 30 %. It is affected by the used equipment and air temperature (in colder weather more branches break). In this study the maximal degree of loss (30 %) is used, because felling mostly takes place in the winter. From the currently growing forests spruce and pine trees in Latvia, about 2 655 022 tons would be greenery losses and only about 6195 thousand tons fresh greenery would be usable.

The results obtained with the method described above show approximately how much spruce and pine greenery is currently available in Latvian forests. The amount is considerable and it would be irrational not to use these resources. That does not mean that rapid cutting of all Latvian coniferous at the felling age should be started in order to obtain greenery and for industrial production. Nonetheless we have to reckon that, in the near future, a large part of these trees will be cut as they have reached the age of felling and when overgrown wood loses quality and economic value (except for secular trees). Therefore, it is worthwhile to create the conditions in which this green resource could be used efficiently. The fact that all logging residues would never be utilized must be considered as a key element in the economic reasoning behind the extraction and utilization of resources.

In order to determine whether there would be enough coniferous greenery of felled coniferous trees, where they are collected, a case of year 2012 in Latvia was studied. According to the State Forest Service data [9], the coniferous trees were cut more extensively than others in 2012, they constituted 52 % of the total volume of timber felled in 2012. Felled spruce wood amounts rose to 16 %, but pine is cut more than twice as much (36 %). Pines are mainly cut in state forests, while spruce are cut in equally large–scale amount in both public and private forests. The total number of the pine wood cut in 2012 is 4 192 277 m^3, spruce amounts to 1 884 232 m^3. These data is used for the calculations of coniferous greenery.

The amount of greenery is determined using the previously mentioned method (the amount of greenery per m^3 bole wood). From felled pines, whose total timber volume was 4 192 277 m^3, there was 326 998 tons of fresh greenery. From spruce cut in 2012, which total timber volume was 1 884 232 m^3, there was 221 774 t of fresh greenery. Together they represent 548 772 tons. If it is assumed that the loss is approximately 30 % (164 632 t), and if the whole coniferous tree felling is used, there would be an opportunity to get about 384 thousand tons of fresh coniferous greenery.

3. Results and discussion

Following the method above it is possible to determine the approximate quantity of coniferous greenery in other Baltic countries – Lithuania and Estonia. The available raw data (the amount of felled spruce and pine wood

m^3/year) of these countries are from different years – for Lithuania from year 2011, while for Estonia the latest such particular information is available from 2007. Data on the felling of coniferous wood for Latvia was the most accurate and recent – from 2012. The greenery amount calculations for the Baltic countries that were carried out using the previously described method are summarized in Table 2.

Table 2. Amount of felled coniferous wood in the Baltic countries m^3/year and the amount of obtainable greenery [10–12]

Country	The amount of felled pine, m^3	The amount of felled spruce, m^3	Greenery from pine, t	Greenery from spruce, t	Losses 30 %	Yearly amount of coniferous greenery, thousand t
Latvia	4 192 277	1 884 232	326 998	221 774	164 632	384
Lithuania	1 031 000	1 144 000	80 418	134 649	64 520	151
Estonia	716 000	1 628 000	55 848	191 616	74 239	173
Total	5 939 277	4 656 232	463 264	548 039	303 391	708

Using the method described above for the calculation of the amount of coniferous greenery, it can be assumed that about 700 thousand m^3 coniferous greenery could be obtained from the annually felled coniferous trees in the Baltic countries. The results do not provide precise information about the amount of greenery which could be obtained from the annually felled coniferous trees in any given year, if they would be collected, but only provides a concept of these volumes. Especially, if we consider that the Baltic forest felling volumes have not been increasing or declining rapidly over the last years, but staying at the same level.

It can be seen that the total amount of felled coniferous wood fluctuated between 11 727 thousand m^3 in 2008 to 17 479 thousand m^3 in 2003. So the amplitude of difference is 5 752 thousand m^3. In the Baltic States, the average of 14 918.5 thousand m^3 coniferous wood is obtained yearly, the largest amount of which is invariably felled in Latvia, and about half as much in other Baltic countries. This is the fact, which should be taken into account in assessing the possibilities of the use of coniferous greenery production, because the major resource stocks are available in Latvia. This country also has a geographically advantageous location, if coniferous greenery would be transported from Lithuania and Estonia.

Statistical data show that coniferous wood cutting in the Baltic States is not always constant. The smallest amount was cut in 2008, when the Baltic countries where hit by the economic crisis. Apparently it also affected the market of timber resources and, consequentially, the felling. Afterwards felling amounts have climbed rapidly, reaching, but not exceeding, previous volumes; however, after 2013 the trend started to drop again. This decline is the result of the decreased felling amount in Latvia. The most stable coniferous wood felling of all Baltic countries has been in Lithuania. In recent years, felling volumes have become more stable in Estonia as well. Taking into account the coniferous wood felling statistics in the Baltic countries from the past decade, the average coniferous wood amount for each year is about 16 million m^3.

As mentioned above, all available greeneries from felled coniferous trees cannot be collected and utilized; the main constraint is the resource extraction and economic feasibility of their utilization. The potential impact of the location of these resources and the extent of the owner's interest, price, shipping distance, labour and other costs also have significant influence. But, what is most important is that in order to use this resource, it is necessary to find an appropriate and economically justified utilization.

4. Conclusions

General methods for determining approximate results should be used for identification of the available amount of coniferous tree greenery in the Baltic States.

For the use of general methods for coniferous tree greenery amount predictions, it is necessary to know the coefficients for coniferous tree greenery to one unit (ha, m^3, or m^2). The coefficients depend on many factors, e.g. on trees' growing regions and climatic zones. The growth conditions also affect the greenery amount. The factors are determined experimentally and are used for a particular region.

In the Baltic States, 78 kg of greenery may be applied on 1 m^3 pine wood, and approximately 117.7 kg on 1 m^3 of spruce wood. Therefore, by within a period of one year it might be possible to get 700 million tons of coniferous tree greenery in the Baltic States, more than half of which (~ 384 million tons) – in Latvia.

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